

Bulletin of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. LX. No. 1.

NEW AND OLD SILURIAN TRILOBITES FROM SOUTH-
EASTERN WISCONSIN, WITH NOTES ON THE
GENERA OF THE ILLAENIDAE.

BY PERCY E. RAYMOND.

WITH FOUR PLATES.

CAMBRIDGE, MASS., U. S. A.:
PRINTED FOR THE MUSEUM.

JANUARY, 1916.

No. 1.— *New and old Silurian Trilobites from Southeastern Wisconsin, with Notes on the Genera of the Illaenidae.*

BY PERCY E. RAYMOND.

IN the F. H. Day collection, received in January 1881, as a gift of Mr. Alexander Agassiz, the Museum of Comparative Zoölogy secured one of the three great collections of the Silurian fossils of southeastern Wisconsin. It is particularly rich in Illaenidae, but contains also such rare forms as *Harpes telleri*, *Trochurus nasutus*, and *Dicranopeltis telleri*, to be found elsewhere only in Mr. Teller's magnificent collection.

The trilobite fauna of the quarries around Milwaukee and Racine differs considerably from that found in the vicinity of Chicago, so that some of the species described by Weller from the latter area are either absent from the M. C. Z. collection or represented by specimens from other sources than the Day collection. The Phacopidae have been omitted from the present study, and only such species are mentioned as are represented by specimens which add something to what has already been published.

ILLAENIDAE Hawle and Corda.

The Illaenidae form a remarkably homogeneous group, and in spite of the great number of species which have been described only three generic or subgeneric names (Illaenus, Bumastus, and Thaleops) are in common use. Holm recognized only Illaenus and Bumastus and other writers have been even more conservative, referring all the species to Illaenus. The only serious attempt to subdivide the genus is that made by Salter, who recognized eight subgenera (including Illaenus), but none of Salter's names has ever come into general use, although some of them could be adopted advantageously. In all, seventeen subgenera or genera have been proposed for inclusion in this family, but only seven of these seem to be valid. The names, in chronological order, are:—Cryptonymus Eichwald 1825, Illaenus Dalman 1826, Deucalion Shtsheglov 1827, Bumastus Murchison 1839, Archegonus and Dysplanus Burmeister 1843, Thaleops Conrad 1843, Alceste Hawle and Corda 1847, Rhodope Angelin 1854, Actino-

lobus Eichwald 1860, Panderia Volborth 1863, Illaenurus Hall 1863, Illaenopsis Salter 1866, Ectillaenus, Hydrolaenus, Octillaenus Salter, 1867, and Illaenoides Weller 1907. Certain other genera, such as Symphysurus and Nileus have often been placed with Illaenus, but they have more generally been recognized as belonging to the Asaphidae. The fundamental difference between the Illaenidae and the Asaphidae is, of course, the presence in the former family of an epistoma, and its absence in the latter. The absence of the grooves on the pleura of the thorax in the Illaenidae and their very general presence in the Asaphidae affords quite a safe criterion for judging of the dorsal surface.

The genera enumerated above may be taken up in order.

CRYPTONYMUS Eichwald, 1825.

Observations geognostico-zoologicae per Ingriam marisque Baltici Provincias nec non de Trilobites. Casani, 1825, p. 44.

In this paper, Eichwald, evidently not understanding Brongniart's genus Asaphus, describes the new genus *Cryptonymus*, and under it, eight species. The first four are species of Asaphus and the last four are species of Illaenidae. Asaphus had been described in 1822, but Illaenus was not published till 1826, so that, if the four asaphids were eliminated, it would really leave an illaenid as the type of *Cryptonymus*. The first of the illaenids described, *Cryptonymus rosenbergi*, is a Bumastus, the second, *Cr. wahlenbergi*, third, *Cr. rudolphii*, and the last, *Cr. parkinsonii*, are all species of Illaenus. To choose among these a type for *Cryptonymus* would be to upset one of two well-established names without any possible gain. Eichwald himself accepted Illaenus as the name of these species, and in 1840 transferred his name *Cryptonymus* to *Trilobites punctatus* Wahlenberg, a proceeding which he afterward stoutly defended (1855). If a new generic name is at any time necessary for any of the eight species described by Eichwald, *Cryptonymus* is still available, but till such a contingency arises, it seems best not to revive the name.

ILLAENUS Dalman, 1826.

Type, ASAPHUS CRASSICAUDA Wahlenberg.

Om Palaeaderna eller de sa kallade Trilobiterna. Kgl. Vet. akad. Handl., 1826, p. 248.

Dalman divided *Asaphus* into four sections, the third of which he designated as *Illaenus*, using the name in a subgeneric sense. *Illaenus* he divided into two divisions. Divisio 1, Cornigeri, contained the single species *Asaphus (Illaenus) centrotus*, which Burmeister made the type of *Dysplanus* in 1843. Divisio 2, Mutici, contained *Asaphus (Illaenus) crassicauda* and *A. (Illaenus) laticauda*. * The first of these has by general consent been made the type of *Illaenus*. Holm has, in several papers, redescribed the typical species, so that its characteristics are well known. Beside the characters of the family, the species shows a short and wide, strongly convex and curved cephalon and pygidium, both without concave borders, large prominent eyes which are situated far back, deep but short glabellar furrows, short but rather wide free cheeks without spines on the genal angles. The thorax has a narrow axial lobe and ten segments. The pygidium has a short but prominent axial lobe, and is wider than long. As Clarke has pointed out, *Illaenus americanus* Billings is an American species which is very similar to *I. crassicauda*, and it seems that only such species as conform to the kind of structure exhibited by the type should be admitted to the restricted genus *Illaenus*.

DEUCALION Shtsheglov, 1827.

Sur les Trilobites en général et en particulier sur ceux de Zarskoë-Selo. Journ. für neue Entdeckungen in der Phys. Chem. Natur. und Technologie St. Petersburg, 1827, no. 1, 2, p. 234, pl. 7, f. 9 a-c.

I have not seen this paper, but judge from what Holm says that *Deucalion* is a synonym of *Illaenus*. The genus was founded on a new species, *D. bronngiarti*, which Holm was unable to recognize.

BUMASTUS Murchison, 1839.

Type, *BUMASTUS BARRIENSIS* Murchison (Partim).

Silurian system, 1839, p. 656 (non figs.).

The particular features of this genus upon which Murchison himself laid most stress were the absence of dorsal furrows, and the presence of ten segments in the thorax. The general usage, however, has been that of referring all illaenids having the axial lobe of the thorax very

broad, its width equaling or exceeding one half the total width of the body, to the genus *Bumastus*. This practice will probably prevail, for we now know that other illaenids beside *Bumastus* have ten segments in the thorax, and there is no illaenid known from which dorsal furrows are absolutely absent. In view of the somewhat numerous subdivisions of the illaenids, it may be well to reëxamine the type-species, *Bumastus barriensis* Murchison, in a little detail. Salter has explained that the specimens figured by Murchison really do not belong to this species, so that we are obliged to use Salter's figures of the "Barr Trilobite." Fortunately the M. C. Z. collection contains two plaster casts of the original specimen figured by Jukes in 1829 and later by Salter. The casts are rather carelessly made, but are in general in fair agreement with Salter's figures. From these sources may be derived the statement that the typical species of *Bumastus* is a large Silurian illaenid with smooth, subequal cephalon and pygidium, rounded, spineless genal angles, large eyes, situated near the posterior margin of the cephalon, a very wide axial lobe, shallow dorsal furrows, ten segments in the thorax, and no trace of an axial lobe on the pygidium. The dorsal furrows on the cephalon are short, extending but little ahead of the eyes. The cephalon does not appear to have any rim or concave depression, but the pygidium shows a slight concavity, so that the profile of that member does not present a smooth convex curve, but the curvature is reversed near the posterior end of the pygidium. Both cephalon and pygidium are wider than long.

ARCHEGONUS Burmeister, 1843.

Die organisation der trilobiten, 1843, p. 120, 121, pl. 5, f. 3.

The type of this genus is *Calymene ? aequalis* H. von Meyer, as this was the only species cited by Burmeister in the first edition of his *Organisation der trilobiten*. As the type is evidently not an illaenid, but one of the Proetidae, the genus automatically disappears from the family.

DYSPLANUS Burmeister, 1843.

Die organisation der trilobiten, 1843, p. 120.

Type, *ILLAENUS CENTROTUS* Dalman.

The type of this genus is an illaenid with rather long, parabolic head and abdomen-shields, spines at the genal angles, small eyes far

back, narrow axial lobe, and nine segments in the thorax. The profiles of both shields are rather flat but uniformly convex curves. (See especially Holm, *Bihang Kogl. Vet. akad. Handl.*, 1883, 7, pl. 4, f. 1-12). Holm was not able to see any value in this genus, pointing out that the only real characteristic brought forward by Burmeister and by Angelin was the presence of genal spines, and the species with genal spines are so highly variable among themselves as to suggest that this character in itself does not denote any real relationship. It seems, however, that a certain group of illaenids can properly be denoted by this term, and the genus will be referred to later.

THALEOPS Conrad, 1843.

Proc. Acad. nat. sci. Phil., 1843, 1, p. 331.

Type, THALEOPS OVATA Conrad.

The presence in this species of very high eyes on long peduncles, long narrow genal spines, deep dorsal furrows sharply delineating a prominent glabella, a narrow axial lobe, ten thoracic segments, and a small short pygidium, mark an unusually well-defined genus which seems to be confined to North America, and probably to the Ordovician, though one Silurian species has been referred to the genus.

ALCESTE Hawle and Corda, 1847.

Prodr. monog. Bohm. tril., 1847, p. 66, pl. 4, f. 31.

Type, ALCESTE LATISSIMA Hawle and Corda (which is the same as *Illaenus hisingeri* Barrande, according to Barrande).

This genus is not valid, for it was based upon an immature specimen showing only four segments, and was very incorrectly described and figured. Without Barrande's explanation, no one would be able to identify the *Alceste latissima* with any Bohemian trilobite.

RHODOPE Angelin, 1854.

Pal. Scandinavia, 1854, pt. 1, *Trilobita*, p. 38, pl. 22, f. 17.

Type, RHODOPE LINEATA Angelin.

The name Rhodope was used for a gastropod by von Siebold in 1848 (*Anatomic*, p. 296), and Volborth replaced the name by *Panderia*.

ACTINOLOBUS Eichwald, 1860.

Type, ILLAENUS ATAVUS Eichwald, 1857.

Lethaea Rossica, 1860, 1, p. 1488.

The type is an illaenid which seems sufficiently peculiar to deserve a distinct generic name. The cephalon is short and the pygidium long, and both cephalon and pygidium have a concave border; the cephalon a narrow lip, and the pygidium as wide a border as the average *Isotelus*. The eyes are rather large, far back and far apart, free cheeks small, genal angles rounded. The dorsal furrows of the cephalon are short, the axial lobe of the thorax is narrow; ten segments are present; and the axial lobe of the pygidium is short and triangular. *Actinobolus atavus* is a Russian Ordovician species (C1a), and another species with a wide border on the pygidium is the one from the Silurian described by Schmidt as *Illaenus masckeii* (From F, Estland).

PANDERIA Volborth, 1863.

Type, PANDERIA TRIQUETRA Volborth.

Mem. Acad. imp. sci. St. Petersburg, 1863, 6, no. 2, p. 31.

Although proposing this name primarily to replace the preoccupied *Rhodope* of Angelin, Volborth made his own new species the type, and the genus must rest upon it. Holm does not actually use *Panderia*, but he seems to have considered it a fit receptacle for the group of small trilobites with only eight thoracic segments, and gives (1883, p. 161) a new definition according to his interpretation of the genus. The presence of only eight segments in the thorax does not appeal very strongly to the present writer as a generic characteristic. *Panderia triquetra* does, however, present some rather unusual characteristics in its very short, strongly convex cephalon with extremely large eyes, the high, well-defined glabella, and the short pygidium with long, prominent axial lobe. Species of this type are not at all common, and may be referred to *Illaenus* without doing violence to the definition of that genus.

ILLAENURUS Hall, 1863.

Type, ILLAENURUS QUADRATUS Hall.

16th Rept. N. Y. state cab. nat. hist., 1863, p. 176, pl. 7.

Although Hall believed this species to be closely allied to *Illaenus*, as indicated by the name, it seems more probable that it belongs to the *Asaphidae* and is allied to *Symphysurus*.

ILLAENOPSIS Salter, 1866.

Type, ILLAENOPSIS THOMSONI Salter.

Mem. Geol. surv. Gt. Britain, 1866, 3, p. 256.

As has been repeatedly pointed out, the grooved pleura of the thorax of this trilobite exclude it from the *Illaenidae*, and place it near *Symphysurus* in the *Asaphidae*.

OCTILLAENUS Salter, 1867.

Type, ILLAENUS HISINGERI Barrande.

Monog. Brit. Silurian trilobites, 1867, pt. 4, p. 182.

This genus was erected by Salter to contain the type, a species in which the pleura of the first thoracic segment are produced into spines. There are eight segments in the thorax, the axial lobe is narrow, the glabella well defined, eyes of medium size and far back, free cheeks with sharp genal spines. Pygidium about as long as wide, without defined axial lobe. This species could probably be placed with *Dysplanus*, but I would follow Salter in the recognition of the remarkable development of spines on the first thoracic segment, it being a unique example of such a characteristic among the smooth trilobites.

ECTILLAENUS Salter, 1867.

Type, ILLAENUS PEROVALIS Murchison.

Monog. Brit. Silurian trilobites, 1867, pt. 4, p. 182.

Holm has pointed out that in proposing this genus Salter confused the true *I. perovalis* of Murchison and a new species afterward de-

scribed by Hicks as *I. hughesi*, and not understanding clearly the characteristics of either species, produced a name of no particular value. The name should be dropped, unless it can be shown to be of more value than now appears to be probable.

HYDROLAENUS Salter, 1867.

Type, ILLAENUS CONIFRONS Billings.

Monog. Brit. Silurian trilobites, 1867, pt. 4, p. 182.

The type-species is a Thaleops, and Hydrolaenus is therefore a synonym of that genus.

ILLAENOIDES Weller, 1907.

Type, ILLAENOIDES TRILOBUS Weller.

Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 226.

The type of this genus is remarkable chiefly for its small eyes which are situated halfway to the front of the head. The glabellar furrows are narrow and shallow, the facial suture cuts the cheeks very close to the genal angles, making the free cheeks of unusual shape. The genal angles are rounded. The axial lobe of the thorax is wider than in typical Illaenus, but less wide than in Bumastus. The pygidium is long with a narrow concave border, but no trace of an axial lobe. Type and only known species from the Niagaran at Bridgeport (Chicago), Illinois.

Summary.—It appears that of the genera proposed, Illaenus, Bumastus, Thaleops, Actinolobus, and Illaenoides have unquestionable value. Dysplanus and Octillaenus are more or less valuable but need further study and redefinition. Cryptonymus, Deucalion, Panderia, and Ectillaenus are names which cannot be used at present, but might possibly be revived. Archegonus, Illaenurus, and Illaenopsis belong to other families. Alceste was never properly defined. Rhodope was preoccupied, and Hydrolaenus is a synonym. It is interesting to note the lapse of forty years between Salter's new names and the next generic name applied to a member of this group.

It is evident that the type-genus Illaenus contains the great majority

of the species in this family, the other genera having, as a usual thing, only from one to two or three species each. *Bumastus* comes next to *Illaenus* in the number of species, and has its greatest development in America where there are at least six species in the Middle Ordovician and about fifteen in the Middle Silurian, as contrasted with three or four species in the Silurian of Great Britain, about the same number in Scandinavia and Russia, and two in Bohemia.

Considering the great abundance of the illaenids, we have surprisingly little information as to their ancestry or relationships. Following the usual theory, which seems to be borne out by the facts in most cases, one would expect these smooth forms to be the descendants of more normal trilobites with glabellar furrows and with ribs on the pygidium. But among all the illaenids there does not seem to be one which shows any trace of ribs on the pygidium, while only a few show indications of glabellar furrows. And such indications of furrows as exist are merely spots or slight depressions on the smooth glabella. The nearest relatives of the Illaenidae are undoubtedly the Goldiidae (Bronteidae) not the Asaphidae, with which family they have usually been classed. The presence in both the Illaenidae and the Goldiidae of an epistoma, similar hypostomas, forward expanding glabella, large eyes which are placed far back, unfurrowed pleura in the thorax, and short axial lobe on the pygidium, indicate a very close relationship, some of these characteristics being apparently too fundamental to admit of explanation on the ground of parallelism. The Goldiidae, in spite of their specialization, are more like the typical trilobite than the Illaenidae, and it would be natural to place them in the ancestral position. The geological range at once negatives this attempt, for the Goldiidae did not appear until the Middle Ordovician, are very rare in the Ordovician and reached their greatest development in the Silurian and Devonian. The illaenids, on the other hand, appeared in the basal Ordovician, possibly even in the Cambrian, reached their greatest development in the Middle Silurian and did not survive that period. That the Goldiidae should have been derived from the Illaenidae, however, seems highly improbable, for the phylogeny of the former family pursues a normal course, the oldest members of the family being most highly segmented, and the usual "smoothing out" process producing such (relatively) *Illaenus*-like species as *Goldius dormitzeri*, *G. campanifer*, and *G. bronngiarti* in the Devonian of Bohemia. If these species, without glabellar furrows and with highly convex almost ribless pygidia occurred in the Ordovician, and forms like *Goldius lunatus* (Billings) in the Devonian, we

should probably conclude at once that the Goldiidae were derived from the Illaenidae.

The oldest illaenids which are well known are those which Barrande described from the base of the Ordovician in Bohemia. Of these, *Illacnus advena* is a quite typical Illaenus, while the other species are peculiar. *Illacnus bohemicus*, the type of which is in the M. C. Z., was founded on a badly preserved single specimen, which does not seem to be an Illaenus. The pygidium shows a long, distinct, and ringed axial lobe and if this member were found alone, it would at once be assigned to the Asaphidae. The nine segments of the thorax are, however, without pleural furrows. The cephalon is too poorly preserved to indicate any characters of value. Long wide genal spines are present, the glabella appears to have nearly parallel sides until the vicinity of the anterior end is reached, when it expands abruptly. Rather faint glabellar furrows seem to be present. With only this single specimen, it does not seem possible to assign the species to any genus or even family, and it certainly throws no light on the origin of the Illaenidae. Another species from D₁, described by Barrande, is the common *Illacnus katzeri*. This species differs from other illaenids in its eyes. Barrande supposed it to be blind, but Holub has recently shown (Bull. international Acad. sci. Bohême, 1908. German abstract, p. 7, pl. 7) that it has small eyes, situated forward. Both shields are rather flattened, not so strongly incurved as in the typical genus Illaenus, and the pygidium is long and parabolic in outline, thus suggesting Dysplanus. There is nothing, however, to indicate that *I. katzeri* is primitive, but it seems rather, like the Silurian *Illacnoides trilobus*, to be a degenerate form. If the genus is divided at all, this species cannot be considered as congeneric with *Illacnus crassicauda*, and I would suggest that the name *Wossekia* be applied to it, since Wossek, Bohemia, is the locality from which practically all the specimens have been obtained. *Illacnus puer* seems to be, as Brögger was the first to point out, a Symphysurus. *Illacnus calvus* has a peculiar marginal rim. The species is known from a single fragment. *Illacnus aratus* has a narrow glabella, and the eyes are very far apart or absent. It is primitive for an illaenid, but gives no suggestion as to the origin of the group.

A pathologic specimen of Illacnus.—Since this paper was written, I have been enabled, through a grant from the Shaler Memorial fund at Harvard College, to visit northern Europe, and some time was spent in studying the collections in London, Berlin, St. Petersburg, Stockholm, and Christiania. One of the most interesting trilobites seen was the specimen of *Illacnus revelensis* Holm, which was figured

by Holm in his description of the Russian Ordovician Illaenidae (Mem. Acad. imp. sci. St. Petersburg, 1886, ser. 7, 33, pl. 2, f. 5a). This is the only example I have seen among trilobites of a malformation due to moulting. As partially shown in Holm's figure, there is an impressed line between the facial suture and the dorsal furrow on the left side, which follows exactly the course of a facial suture, even extending across the front of the cranidium, a point not shown in Holm's figure. Across the posterior part of the cephalon, close to the edge, is a furrow marking the posterior edge of the shell at the time of the previous moult. The eye on the left side is smaller than its opposite, and the palpebral lobe is malformed. The cephalon is decidedly unsymmetrical, the left free cheek being drawn backward. All these pathological features seem to be due to the partial retention of the shell at the next previous moult.

Classification of the Illaenidae.

From the first, all classifications of the Illaenidae have rested mainly upon the number of segments in the thorax, and secondarily upon the width of the axial lobe of the thorax. Thus, Dalman, the describer of Illaenus, separated the species with nine segments from those with ten. Holm, the principal writer upon the genus, while recognizing only the genus Illaenus and the subgenus Bumastus, divided Illaenus into three groups, those with ten, nine, and eight segments in the thorax. A study of the American illaenids does not favor a classification of this sort, for it has been repeatedly shown that the number of thoracic segments in species of both Illaenus and Bumastus is variable, even within the limits of a single species. Likewise, the presence or absence of genal spines is not a characteristic justifying, in itself, the erection of a genus of Illaenidae, for, as has been several times pointed out, species are found with all sorts and conditions of spines, and if all species having this characteristic were to be referred to a single genus, there would be hardly another characteristic common to the assemblage. The length and convexity of the cephalon and pygidium, the size and position of the eyes, the width of the axial lobe of the thorax, and the shape of the glabella seem of the most importance, but I would also take into consideration the sort of genal spines which may be present. It is still too early to make any natural classification, and the genera here recognized are based primarily upon the more conspicuous peculiarities of the type-species of each.

ILLAENIDAE Hawle and Corda.

Opisthoparia with large, convex, nearly smooth, cephalic and abdominal shields. Epistoma large, hypostoma convex, ovoid. Thorax of eight to ten segments, with unfurrowed pleura. Pygidium without ribs, axial lobe short or absent. Ordovician and Silurian.

ILLAENINAE, subf. nov.

Illaenidae with narrow axial lobe, cephalon and pygidium without concave border.

Illaenus Dalman. Cephalon and pygidium very convex, wider than long, abruptly deflected; eyes large and far back, axial lobe of pygidium high. Genal spines, when present, rounded in section. Type, *Illaenus crassicauda* (Wahlenburg). Ordovician and Silurian. Europe, North and South America, India, and Australia.

Thaleops Conrad. Cephalon and pygidium similar to *Illaenus*, but with eyes on long stalks and elongate genal spines always present. Type, *Thaleops ovata* Conrad. Ordovician and possibly Silurian. North America.

Dysplanus Burmeister. Cephalon and pygidium long and flattened, parabolic in outline, genal spines present, usually flattened. Type, *Illaenus centrotus* Dalman. Ordovician. Northern Europe.

Wossekia, gen. nov. Cephalon and pygidium as in *Dysplanus*, genal spines absent, eyes small and far forward. Type, *Illaenus kätzeri* Barrande. Basal Ordovician. Bohemia.

Octillaenus Salter. Similar to *Dysplanus* but with rounded genal spines, and pleura of first segment elongated into spines. Type, *Illaenus hisingeri* Barrande. Ordovician. Bohemia.

BUMASTINAE, subf. nov.

Illaenidae with (usually) concave border on one or both shields, axial lobe generally wide, though sometimes narrow.

Bumastus Murchison. Axial lobe of thorax equal to more than half the total width; eight to ten segments. Typically, a concave border is present on the pygidium, frequently on both cephalon and pygidium, rarely (in small Middle Ordovician species) without con-

cave border on either shield. Eyes very large. Type, *Bumastus barriensis* Murchison. Ordovician and Silurian. North America. Silurian. Europe.

Actinolobus Eichwald. Axial lobe narrow, cephalon short, pygidium long, with very wide concave border. Eyes large. Type, *Illaenus atavus* Eichwald. Ordovician, Russia. Silurian. Russia and United States.

Illaenoides Weller. Axial lobe with a width between that of *Actinolobus* and *Bumastus*, eyes very small and far forward, narrow concave border on pygidium. Type, *Illaenoides trilobus* Weller. Silurian. United States.

The above classification is designed to separate the species with long more or less flattened shields from the more typical illaenids with short and abruptly deflected cephalon and pygidium. The first two genera are modifications of the central *Illaenus* type, the other three of the more flattened *Dysplanus* group. In defining the subfamily Bumastinae as I have, all the forms with a more or less *Isotelus*-like pygidium are removed from the typical *Illaenus* group. Among the small species constituting the earliest of the Bumastinae one finds species like *B. globosus* Billings, *B. bellevillensis* Raymond and Narraway, and a few others, which lack a concave border. On the other hand, so large a Middle Ordovician *Bumastus* as *B. indeterminatus* (Walcott), the type of which is figured (Plate 2) for the first time, has a distinctly concave border. It is very possibly true that the small species mentioned above should be given a distinct name and placed in the Illaeninae, but it still seems somewhat early to take so radical a step.

Description of species.

We owe to Professor Weller a complete and careful description of the Illaenidae of the Chicago area, and, as he had access to collections made at Racine and near Milwaukee, his description in large measure covers the Wisconsin area also. In the large collections which I have been able to examine, I have, however, found a few specimens more perfect than those previously described, and also a few new species. When first studying the excellent figures given by Weller, one is struck by the apparent triviality of the specific characteristics employed in the discrimination of the species, but with a large collection, it is found that the characteristics are remarkably constant. The study of these illaenids is unusually interesting, in fact, for it seems to be

one of the few cases where characteristics arbitrarily chosen may serve to define natural groups. The bumastids particularly, which are simple trilobites with few variable characters, seem to be susceptible to this sort of treatment. The chief variable characters are amount of convexity, ratio of length to breadth, length of dorsal furrows, presence or absence of "lip" on cephalon and concave border on pygidium, and size of eyes. Almost every possible combination of these few characteristics seems to be present among the species, and each combination is usually exhibited by a large number of specimens. That these variations are not the attributes of one very plastic species but of a number of distinct species is shown by the geographical distribution as well as by the numbers in each group. For example, *Bumastus insignis* seems to be confined to a small area in the immediate vicinity of Chicago, and *B. ioxus* to Joliet, Illinois and Racine, Wisconsin, while *B. cuniculus* is found in vast numbers near Milwaukee, but is rare in the Chicago area. Others of the species are equally local in distribution.

BUMASTUS CUNICULUS (Hall).

Illaenus cuniculus Hall, 20th Rept. N. Y. state cab. nat. hist., 1868, p. 377, pl. 22, f. 12; 1870, rev. ed., p. 421, pl. 22, f. 12. Weller, Bull. Chicago acad. nat. hist., 1907, no. 4, pt. 2, p. 219, pl. 19, f. 1-6.

This is by far the most common species at Wauwatosa, Wisc. There are several nearly complete specimens in the M. C. Z., most of them enrolled. They show the axial lobe of the thorax to be extremely wide, and the dorsal furrows very shallow. There are ten segments. The diagnostic specific characteristics are: — elongate, moderately convex cephalon with very narrow rim which is prominent at the front, but disappears before reaching the genal angles, and eyes of medium size. Dorsal furrows faint, hardly visible at all in front of the scar-like spots just inside the eyes. Pygidium elongate, moderately convex, with practically no depressed border. A flattening of the convexity near the border can be seen if the pygidium is viewed in profile.

Measurements: — A cephalon of average size is 45 mm. long, 55 mm. broad; the eye 9 mm. long, or one fifth the total length. A large cephalon is 56 mm. long. The pygidium of an enrolled specimen whose cephalon is 45 mm. long is 50 mm. long and 52 mm. wide. The axial lobe of this specimen is 42 mm. wide and the total width of the thorax is 53 mm.

Formation and locality: — Very common in the Niagaran at Wauwatosa, near Milwaukee, Wisconsin.

BUMASTUS NIAGARENSIS (Whitfield).

Plate 1, fig. 3.

Illaenus niagarensis Whitfield, Ann. rept. Geol. surv. Wisconsin for 1879, 1880, p. 68. Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 219, pl. 19, f. 7-11.

Illaenus madisonianus Whitfield. Geol. Wisc., 1882, 4, p. 307, pl. 20, figs. 8-9. Foerste, Bull. sci. lab. Den. univ., 1885, 1, p. 106, pl. 14, f. 1a-b, 2a-b; 1887, 2, p. 93, pl. 8, f. 8, 9, 10, 10a; Geol. surv. Ohio, 1893, 7, p. 526, pl. 26, f. 1, 2, varieties, pl. 27, f. 7-10. Van Ingen, School of mines quarterly, Columbia univ., 1901, 23, p. 35.

This seems to be one of the few illaenids of the Chicago-Wisconsin Niagaran area which has hitherto been known from entire specimens. Whitfield figured an entire one, Weller had a nearly complete specimen, and there are five in the M. C. Z. (Day collection). One of these is figured as it shows some characters not shown in either Whitfield's or Weller's figure. Whitfield's figure, if it really represents this species, is inaccurate in respect to the glabellar furrows, which are really much longer than is indicated by his figure or description. From the general proportions of the body, and the position of the eyes, it would seem that his figure really does represent this species. The specimen here figured is a little longer and narrower than those previously figured, and has a longer and more pointed pygidium.

It will be noted that the thorax is exceedingly short, though ten segments are present. The dorsal furrows do not show in the figured specimen, but they do on another specimen in the M. C. Z. collection, and are also indicated in Whitfield's figure.

The specific characteristics are:—cephalon rather convex, with long dorsal furrows, no lip or concave border on the cephalon. Eyes of medium size, situated nearly their own length from the posterior margin, thorax short, pygidium long, rather pointed behind, with narrow concave border.

Measurements:—The specimen (Plate 1, fig. 3) is 58 mm. long; cephalon 22 mm. long, 31 mm. wide; thorax 13.5 mm. long; pygidium 29 mm. long, 29 mm. wide; the eyes are damaged. On a very good enrolled specimen preserving the test, the cephalon is 24 mm. long, the eye 5 mm. long, and 5 mm. from the posterior margin. On a larger specimen the eye is 1 mm. more than its own length from the posterior margin.

Formation and locality: — This species is quite common in the Niagaran at Wauwatosa, though not nearly so common as *B. cuniculus*.

BUMASTUS DAYI, sp. nov.

Plate 1, fig. 8-10.

The Day collection contained two fine specimens labeled *sp. nov.*, and as they have proven to be such I have named them in honor of the collector. The specific characteristics are: — cephalon and pygidium short and convex, eyes large and far back, no lip or concavity at the front of the glabella, though there is one at the sides of the free cheeks, dorsal furrows of the cephalon long, reaching the pits in front of the eyes.

Thorax of ten segments, axial lobe very wide, furrows shallow. Pygidium short and evenly convex, with only a trace of a concave margin.

It will be at once noted that this species is much like *B. niagarensis*, but has large eyes far back, and the pygidium is shorter and with less depressed margin. It differs from *B. cuniculus* in having long instead of short dorsal furrows on the cephalon, and in lacking the rim at the front. Of the species found near Chicago, *B. chicagoensis* (Weller) is very similar to this but that species has a much shorter and more abruptly deflected cephalon.

Measurements: — The type is 46 mm. long; cephalon 19 mm. long, 26 mm. wide; eye 7 mm. long and 2 mm. from posterior margin; thorax 14 mm. in length; pygidium 23 mm. long, 25 mm. wide. A large cephalon is 34 mm. long, 46 mm. wide; eye 11 mm. long, 4 mm. from posterior margin.

Formation and locality: — Quite common in the Niagaran at Wauwatosa, Wis.

BUMASTUS DECIPIENS, sp. nov.

Plate 1, fig. 1, 2.

Exceedingly like *B. dayi* is a species of which the collection contains only five or six specimens, two of which are approximately entire. The specimens are of about the same size as the smaller ones of *B. dayi*, and the principal difference between the two is that *B. decipiens*

has short glabellar furrows and no lip on the free cheek, while *B. dayi* has long furrows and a lip on the free cheek. The eye of *B. decipiens* seems also to be a little longer and further back than in *B. dayi*. The pits in front of the eyes are exceedingly faint.

Bumastus transversalis (Weller) likewise has a short head, large eyes, and short dorsal furrows, but is much wider than *B. decipiens*. *B. armatus* (Hall) is much like *B. decipiens* but has spines at the genal angles.

Measurements: — The holotype (Plate 1, fig. 2) an imperfect cranidium, is 19 mm. long; the eye is 7.5 mm. long, and 2 mm. from the posterior margin. The figured paratype (Plate 1, fig. 1) is about 51 mm. long; cephalon 21 mm. long; thorax 15 mm. long. A second small, unfigured paratype has the cephalon 12 mm. long, 16 mm. wide; eye 5 mm. long; 1 mm. from posterior margin; thorax 8 mm. long; pygidium 12 mm. long, and about 16 mm. wide.

Formation and locality: — All the specimens are from the Niagaran at Wauwatosa, Wisc.

BUMASTUS TENUIS, sp. nov.

Plate 1, fig. 6, 7 and ? 11.

This species is like *B. decipiens*, rare, and the collection contains five specimens showing the cranidium only. It is characterized by its slight convexity and the very wide concave lip at the front. The dorsal furrows are long, reaching to the pit in front of the eyes. These pits are themselves very far forward and close to the margin. The eyes are large and close to the posterior margin.

This species of course suggests *B. cuniculus*, but the lip is much wider, the dorsal furrows longer, and the pits in which they end very close to the margin. It has a flatter cephalon and wider lip than any known *Bumastus*.

A pygidium (Plate 1, fig. 11) which does not seem to belong with any other species found at Wauwatosa is tentatively referred to *B. tenuis*. It is too short and not convex enough for *B. niagarensis*, and has too wide a concave border for *B. cuniculus*, *B. dayi*, or *B. decipiens*.

Measurements: — The type cranidium is 33 mm. long and 34 mm. wide at the palpebral lobes. The eye was approximately 8 mm. long and 2 mm. from the posterior margin.

Formation and locality: — All the specimens are from the Niagaran at Wauwatosa, Wisc.

BUMASTUS INSIGNIS (Hall).

Iliaenus insignis Hall, 18th Rept. N. Y. state cab. nat. hist., 1865, p. 27, f. 5, 6 adv. sheets; 20th Rept. N. Y. state cab. nat. hist., 1868, p. 331, f. 5, 6, pl. 22, f. 13, 14; 1870, rev. ed., p. 419, f. 10, 11, pl. 22, f. 13, 14. Weller, Bull. Chicago acad. nat. sci., 1907, no. 4, pt. 2, p. 215, pl. 17, f. 1-5. Not of Salter, Whitfield, Foerste, and Kindle. (See Weller, op. cit.).

It is interesting to note that though Hall cites Waukesha and Milwaukee, Wisc., first in his list of localities for this species, the species is not known at all from Wisconsin, and the specimens which Hall figured were undoubtedly from near Chicago. Whitfield's *Iliaenus insignis* was *B. cuniculus* (Hall). The English specimens figured by Salter as belonging to this species, show the same long furrows and cephalon with a lip, but the front of the head is not so pointed. The eyes of the English form are likewise less elongate and further back than in specimens from near Chicago. It seems probable that the English form deserves a distinct name, and *B. pomiata*, the name used by Salter on the plate of his publication, is still available.

BUMASTUS IOXUS Hall.

Iliaenus (Bumastus) barriensis ? Hall, Geol. surv. Wisc., 1862, 1, p. 433, (no description); 18th Rept. N. Y. state cab. nat. hist., 1865, p. 28 adv. sheets; 20th Rept. N. Y. state cab. nat. hist., 1868, p. 332.

Iliaenus ioxus Hall, 20th Rept. N. Y. state cab. nat. hist., 1868, p. 387, fig., pl. 22, f. 4-11, pl. 23, f. 1. Whitfield, Geol. Wisc., 1882, 4, p. 304, pl. 21, f. 11, 12. Foerste, Proc. Boston soc. nat. hist., 1890, 24, p. 268, pl. 5, f. 20. Van Ingen, School of mines quarterly, Columbia univ., 23, 1901, p. 35 (no description). Kindle, 28th Ann. rept. Dept. geol. and nat. res. Indiana, 1904, p. 480, pl. 22, f. 7, pl. 23, f. 3. Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 222, pl. 18, f. 1-3.

Iliaenus (Bumastus) ioxus Hall, 20th Rept. N. Y. state cab. nat. hist., 1870, rev. ed., p. 420, f. 12, pl. 22, f. 4-10. ? 11th Rept. Dept. geol. and nat. hist. Indiana, 1882, p. 335, pl. 38, f. 14, non 13; Trans. Albany inst., 1883, 10, p. 76.

The status of the name of this species is somewhat like that of *Cheirurus niagarensis*. In the Pal. N. Y., 2, Hall identified the rather common large *Bumastus* of the Rochester shale as *B. barriensis* Murchison, and in his earlier references to the Wisconsin specimen he

used the same name. When he came to figure a Wisconsin specimen, however, he proposed a new specific name for it, and the name was so obviously suggested by the Wisconsin specimens that I agree with Weller that those specimens should be considered the types of *B. ioxus*.

Professor Weller has suggested that the specimens from New York may belong to another species. I have investigated the point as fully as the material at my command would permit, and have not so far been able to find any really good characteristics on which to base a separation. The best specimens from New York are usually small, and considerably flattened. The study of better material will probably reveal characteristics not now evident, and I have therefore omitted from the synonymy the references to the New York specimens.

Hall figured a pygidium which he assigned to the species, undoubtedly correctly, but up to the present the thorax has been unknown. The M. C. Z. (Day collection), contains a large specimen, whose label states that it is the "only perfect specimen found at Racine." It is not exactly a perfect specimen, though it retains cephalon, parts of ten thoracic segments and the pygidium. The axial lobe of the thorax is somewhat less wide than one would have expected from the large size of the animal, but, being 62% of the total width, is about the general average among the bumastids. The pygidium does not show an actual concave border, but there is a very decided flattening of the curve of the profile at the back.

As the specimen is preserved, the pygidium is somewhat unnaturally drawn in, so that the actual length is not shown. On the other hand, the last thoracic segment is displaced from the others and there is a considerable space between the thorax and cephalon at the anterior end, and between the thorax and pygidium behind. The length of this specimen, therefore, gives only a rough approximation of the correct length. Incidentally it should be noted that the cephalon of this species has a large median tubercle near the posterior margin. It is shown in Hall's figure, but omitted from Weller's.

Measurements: — Length, about 180 mm.; cephalon 75 mm. long, 110 mm. wide; thorax about 75 mm. long, about 100 mm. wide at middle, axial lobe 62 mm. wide; pygidium 65 mm. long, 102 mm. wide. A well-preserved pygidium is 68 mm. long and 100 mm. wide.

Formation and locality: — Hall mentions Waukesha and Wauwatosa as localities for this species, but in very extensive collections from these places no specimens of this species are present, while we have a number of specimens from the Racine dolomite at Racine, Wisc.

BUMASTUS GRAFTONENSIS Meek and Worthen.

Illaenus (Bumastus) graftonensis Meek and Worthen, Proc. Acad. nat. sci.

Phil., 1870, p. 54; Geol. surv. Illinois, 1875, 6, p. 508, pl. 25, f. 4.

Bumastus sp. ind. Meek and Worthen, Geol. surv. Illinois, 1875, 6, pl. 24, f. 3.

Illaenus graftonensis Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 223, pl. 16, f. 4-6.

Only the cephalon of this species has previously been known, but the Day collection contains two complete, though somewhat flattened specimens from Waukesha, Wisconsin, where this species seems to be fairly common.

The cephalon is too well known to need further description, except to note that as in *B. ioxus*, there is a prominent median tubercle between the eyes and near the posterior margin.

The thorax has ten segments, a broad axial lobe, rather well-defined dorsal furrows. The pleura of the thoracic segments are more prominent and ridged, and not so flat as in most species of *Bumastus*. The pygidium is short and moderately convex, with a flattening around the margin, but not a real concave border. The pygidium resembles that of *B. ioxus*, but is shorter and wider, the average ratio of length to width in *B. ioxus* being .64 and in the two pygidia of *B. graftonensis* which we have, .54.

Formation and locality: — Nine specimens (M. C. Z. coll.) are from the Niagaran at Waukesha, Wisc., a locality from which this species has not previously been reported.

BUMASTUS INDETERMINATUS (Walcott).

Plate 2.

Illaenus indeterminatus Walcott, 31st Ann. rept. N. Y. state mus. nat. hist., 1877, p. 19 adv. sheets; 31st Ann. rept. N. Y. state mus. nat. hist., 1879, p. 70.

Illaenus cf. *I. indeterminatus* Clarke, Pal. Minn., 1897, 3, pt. 2, p. 716, f. 24.

Bumastus indeterminatus Raymond and Narraway, Ann. Carnegie mus., 1908, 4, p. 253, pl. 62, f. 8, 9.

The M. C. Z. contains the type of this species, and it is figured (Plate 2) for the first time. The specimen consists of a good cephalon, part of one free cheek, a very much dislocated thorax, of which only seven segments can be definitely made out, and a very fine pygidium.

The pygidium is considerably longer and more convex than the cephalon, and the axial lobe is evidently very wide and without very strong dorsal furrows.

The dorsal furrows of the cephalon fade out just before reaching the pits in front of the eyes, but this is probably an individual variation. These pits are not directly in front of the eyes as in most species of *Bumastus*, but considerably inside the projection of a line drawn through the length of the eye.

The pygidium is very convex, with concave slopes to the lateral and posterior margins.

Formation and locality: — The type, M. C. Z. no. 650, is from Russia (Newport), Herkimer Co., New York. The horizon is the Leray-Black River (Ordovician).

ACTINOLOBUS AMERICANUS, sp. nov.

Plate 1, fig. 4, 5.

The M. C. Z. contains a single pygidium which, on account of its great length and wide flat border, is referred to *Actinolobus*, a genus previously unrepresented in this country. The specimen is damaged on the right side and has been restored in plaster.

There is also a break on the left side not shown in the figure, but the outline is believed to be accurate. The specimen is 38 mm. long and 20 mm. wide at the front. At the widest part, the border has a width of 10 mm. and is somewhat concave. The central part of the pygidium is strongly convex. The anterior margin indicates that the axial lobe of the thorax was wide, though not so wide as in the species of *Bumastus* found with it.

Formation and locality: — From the Racine dolomite at Racine, Wisconsin.

LICHADIDAE Hawle and Corda.

TROCHURUS NASUTUS (Weller).

Plate 3, fig. 1, 2.

Dicranopeltis nasuta Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 240, pl. 22, f. 5-7.

A figure of the specimen of this species in the Day collection is introduced in order to show the way in which the frontal lobe of the

glabella tapers into a spine, this feature not being correctly shown by Weller's figures. I had at first believed that this specimen represented a distinct species, but fortunately was able to see the type in Mr. Teller's collection. That the species belongs to *Trochurus* instead of *Dicranopeltis* is shown by the dorsal furrows, which curve inward instead of outward, at the posterior ends.

Formation and locality:—The specimen is from the Niagaran at Wauwatosa, Wisconsin.

ODONTOPLEURIDAE Burmeister.

CERATOCEPHALA GONIATA Warder.

Plate 3, fig. 3-5.

Ceratocephala goniata Warder, Amer. Journ. Sci., 1838, ser. 1, 34, p. 378, fig.

Clarke, 44th Rept. N. Y. state mus. nat. hist., 1892, p. 91-100, pl. 1, f. 1. Kindle, 28th Ann. rept Dept. geol. and nat. res. Indiana, 1904, p. 480, pl. 24, f. 13. Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 255, pl. 23, f. 1-2. Raymond, Bull. Victoria mem. mus., 1913, 1, p. 38.

Acidaspis danai Hall, Geol. Surv. Wis., 1862, 1, p. 432 (no description); 18th Rept. N. Y. state cab. nat. hist., 1865, p. 28, adv. sheets; 20th Rept. N. Y., state cab. nat. hist., 1868, p. 333, pl. 21, f. 8-9; 1870, rev. ed., p. 423, pl. 21, f. 8, 9.

Acidaspis ida Winchell and Marcy, Mem. Boston soc. nat. hist., 1865, 1, p. 106, pl. 3, f. 13.

The cephalon of this species is, thanks to Professor Weller, now well known, but hitherto the thorax and pygidium have not been noticed. The Day collection in the M. C. Z. contains parts of two pygidia and a fragment showing a portion of five segments of the thorax. The pygidium is like that of *Acidaspis portlocki* Barrande, with a large median spine, on each side of which are two smaller spines, then a large spine, and finally an outer small spine. Each spine gives off small thorns on each side. The thorax is similar to that of *C. verneuili* Barrande. However, as only the central portion has been seen this part of the body would not be expected to show specific characteristics. The cephalon seems to be more nearly allied to *C. vesiculosa* than to *C. verneuili*, and a cephalon in the M. C. Z. gives indication that marginal spines were present on the free cheeks. The pygidium found with the cranidia at Wauwatosa are unlike those ascribed to *C. vesiculosa* by

Barrande, and, on the other hand, though the pygidia in the Day collection are much like that of *A. portlocki*, their cephalons are very unlike those assigned to *A. portlocki* by Barrande.

Formation and locality:—The specimens figured are from the Niagaran at Wauwatosa, Wisc.

ENCRINURIDAE Angelin.

ENCRINURUS REFLEXUS, sp. nov.

Plate 3, fig. 7, 8.

The Day collection contains several pygidia of an *Encrinurus* which is larger and differs in various ways from any species of this genus heretofore described from Silurian strata of this country.

Cephalon and thorax unknown.

Pygidium large for the genus, triangular, pleura bent abruptly downward, the posterior end somewhat turned up. Axial lobe very long, tapering backward to a point. It is marked by about thirty rings which are prominent and sharp toward the front, but very faint at the posterior end. With the exception of two at the anterior end the rings do not cross the axial lobe, but leave a narrow smooth space along the median line. Along this smooth lane are disposed eight pustules, approximately evenly spaced. On the pleural lobes are eight pairs of broad flat ribs which curve backward, making a rather abrupt turn near their outer ends. They do not reach quite to the margin, and end in blunt free spines which project from the sides a little above the margin. At the posterior end the last two ribs from each side converge alongside the axial lobe, and, with a small median spine, project beyond the end of the axial lobe. The ribs have small pustules scattered somewhat irregularly over them, and not aligned in longitudinal rows. Nearly every rib has a pustule at its inner end and one near the middle. Some of the ribs have only these two, but the longer ones near the front have another.

Measurements:—The more complete of the cotypes is 28 mm. long, 26 mm. broad at the front. The axial lobe is 9 mm. wide at the front and 26 mm. long.

Comparison with other species:—Nine species of *Encrinurus* have previously been described from the Silurian of America, but most of them are of much smaller size than the present species and only two

species, *E. deltoideus* Shumard and *E. nereus* Hall, have as many as eight pairs of ribs. Most of the species have seven pairs, one, *E. americanus* Vogdes, has six, and *E. elegantulus* Billings has only five. The species may be taken up in alphabetical order.

E. americanus Vogdes (Description new Crustacea from Clinton of Georgia, 1866, p. 1), has only six pairs of ribs on the pleura, and no pustules, thus ruling it out at once.

E. deltoideus Shumard (Geol. Missouri, 1855, p. 198, pl. B, f. 10), is similar in many ways to *E. reflexus*, having the rings very numerous, twenty-four in number, and interrupted by a smooth lane. There are, however, no pustules except very indistinct granules, on this lane, and the ribs, of which there are eight pairs, are likewise smooth.

E. egani S. A. Miller (Journ. Cinc. soc. nat. hist., 1880, 2, p. 254, pl. 15, f. 1, 1b), has a long terminal spine, only seven pairs of ribs, which are narrow with wide interspaces, and while the axial lobe of the pygidium is on the same plan as in *E. reflexus*, it has fewer rings and tubercles.

E. elegantulus Billings (Cat. Silurian fossils Anticosti, 1866, p. 62), has only five pairs of ribs, the median lane on the axial lobe is without tubercles, but the first eight rings cross it.

E. indianænsis Kindle (28th Ann. rept. Dept. geol. and nat. res., Indiana, 1904, p. 482, pl. 24, f. 14, 15), is a very peculiar species, not at all of the same type as the one under discussion. It has fifteen rings on the axial lobe and ten pairs of ribs. Each rib crosses the axial lobe and has three to five tubercles.

E. nereus Hall (20th Rept. N. Y. state cab. nat. hist., 1868, p. 375, pl. 21, f. 15) has no flattened lane along the top of the axial lobe, and no nodes on the rings or ribs.

E. ornatus Hall and Whitfield (Pal. Ohio, 1875, 2, p. 154, pl. 6, f. 16) is quite similar to the present species, but has only seven pairs of ribs, and the ribs themselves are narrower and the spaces between them wider. There are also only twenty rings and five nodes on the axial lobe.

E. thresheri Foerste (Bull. Sci. lab. Denison univ. 1887, 2, p. 101, pl. 8, f. 26) is a small species which is similar to the last and to *E. reflexus*. There are, however, only seven pairs of ribs, which are themselves exceedingly narrow; there are also only eighteen rings on the axial lobe, and six pustules on the smooth lane.

E. tuberculifrons Weller (Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 259, pl. 24, f. 12, 13) is a small form with a short wide pygidium which is without nodes and the rings of which cross the axial lobe without interruption.

Formation and locality: — From the Niagaran at Wauwatosa, Wisc.

CALYMENIDAE Milne Edwards.

CALYMENE NIAGARENSIS Hall.

Calymene niagarensis Hall, Geol. N. Y., 1843, pt. 4, p. 102, f. 3 on p. 101; tab. org. rem. 10, f. 3.

Calymene blumenbachi var. *niagarensis* Hall, Pal. N. Y., 1852, pt. 2, p. 307, pl. 67, f. 11, 12.

Calymenes are difficult fossils to differentiate satisfactorily, but it is possible to draw a little closer limits to some of the species than has been done in the past. The Silurian species do not present so difficult a problem as do those in the Ordovician, specific characteristics being apparently more fixed and constant in later times. Before venturing to separate two new species, it is best to direct attention for a moment to the well-known (in name) Silurian form.

The name was applied originally by Hall to specimens from the Rochester shale at Lockport, N. Y. The figures and description show the original specimens to have been of the *Calymene blumenbachi* type, that is with a narrow lip in front of the glabella, three pairs of glabellar lobes, and pygidium with an impressed line on each rib, distinctly bifurcating the outer portion. The ribs also reach practically to the margin.

It seems that the species *Calymene niagarensis* should be restricted to such trilobites as show these important characteristics of the types and these may be seen in most of the Calymenes in the Rochester shale. Another Calymene found at the same horizon, *C. vogdesi* Foerste, has the same bifurcated ribs on the pygidium, but a much longer snout-like lip in front of the glabella. It is also a much larger form, one of the largest of the Calymenes.

In the Ordovician the common *Calymene senaria* of the Trenton has the same type of bifurcated rib, while the later *C. meeki* Foerste, so abundant in the Eden and Maysville at Cincinnati, shows only a trace of an impressed line on the ribs, and often the line is absent entirely.

CALYMENE BREVICEPS, sp. nov.

Plate 3, fig. 11.

Calymene niagarensis Hall, 28th Rept. N. Y. state mus. nat. hist., doc. ed., 1877, pl. 32, f. 8-15; mus. ed., 1879, pl. 32, f. 8-15; 11th Rept. Dept. geol. and nat. hist. Indiana, 1882, p. 331, pl. 34, f. 8-15. Hall and Clarke, Pal. N. Y., 1888, 7, pl. 1, f. 10-14.

The *Calymene* abundant at Waldron, Indiana, has always been identified with *C. niagarensis*, but differs from that species in at least two marked details. The first and most obvious characteristic is that there is no lip, nor any furrow between the glabella and the rim, so that the glabella reaches upon, and in some cases, overhangs the rim, a feature usual in the Cheiruridae but extremely uncommon among the Calymenidae. This gives the cephalon the high, short appearance which suggested the name *breviceps*. On the pygidium the ribs reach nearly to the margin but become faint on approaching it. Ordinarily the ribs do not bear any median impressed line though traces of one may be seen on some specimens.

This species is in many ways much like *C. celebra*, the next species described.

Formation and locality: — This species is so far known only from the (Silurian) Waldron shale at Waldron, Indiana, where it is very common.

CALYMENE CELEBRA, sp. nov.

Plate 3, fig. 9, 10.

Calymene blumenbachii var. *niagarensis* Hall, Geol. surv. Wis., 1862, 1, p. 432.
Calymene niagarensis Hall, 18th Rept. N. Y. state cab. nat. hist., 1865, p. 30, adv. sheets; 20th Rept. N. Y. state cab. nat. hist., 1868, p. 334; 1870, rev. ed., p. 425. Weller, Bull. Chicago acad. sci., no. 4, pt. 2, p. 261, pl. 23, f. 9-10.

One of the most abundant of the trilobites of the Chicago area and of southeastern Wisconsin is a *Calymene* which is constantly identified as *C. niagarensis*. It is quite commonly found entire, but always so far as I have seen in the condition of a cast of the interior. Moulds of the exterior are common, but seldom complete.

The cephalon is like that of *C. niagarensis*, with a short lip and narrow furrow in front of the glabella. The dorsal furrows are always very deep and sharp, but this is due to the state of preservation. The glabella tapers rather abruptly toward the front. The basal lobes are large, rounded, almost isolated; the second lobes small and rounded, the intermediate "extra lobes" not very prominent. The third lobes are very small and the fourth ones just barely indicated. The frontal lobe is short and rather square at the front. The eyes are close to the glabella and opposite the furrows between the second and third pairs of lobes.

The pygidium is the most characteristic portion of the animal. The axial lobe is narrow, well defined, and has rings. The pleural lobes show four pairs of narrow ribs, without impressed line, which reach only halfway to the margin. The fourth of the four pairs are very faint and short. Each pleural lobe is thus divided into a small triangular ribbed portion near the axial lobe and a much longer smooth portion below. This pygidium presents the greatest possible contrast to *C. niagarensis*, in which the ribs are more conspicuous near the margin than near the axial lobe. The peculiarities of the pygidium have doubtless been noticed before, and probably have been explained as due to the state of preservation, the specimens all being internal casts. Internal casts of either cephalae or pygidia of trilobites are practically always less and not more smooth than the exteriors, however, and cleaned interiors of *C. senaria*, *C. breviceps*, and *C. meeki*, all show that *Calymene* follows the general rule. *Calymene celebra* shows a halfway stage to what is achieved in *C. clintoni* Vanuxem, namely, a pygidium with smooth pleural lobes. The latter species is too far removed from the *Calymenes* with typical ribbed pygidia to be included in the same genus.

Formation and locality:—*Calymene celebra* is common in the Niagaran of the Chicago district in northern Illinois, in the same portion of the Silurian in southeastern Wisconsin, and also near Madison, Indiana, and Eaton, Ohio.

LIOCALYMENE, gen. nov.

Calymeninae (as distinguished from the Homalonotinae) with distinct glabella, three pairs of glabellar lobes, narrow thorax, pygidium with ringed axial and smooth pleural lobes. Type, *Hemicrypturus clintoni* Vanuxem.

Liocalymene clintoni, in perfect preservation, appears to be an exceedingly rare fossil. The single specimen in the M. C. Z. is in about the same condition as that figured by Hall (Pal. N. Y., 2, p. 298, pl. A 66, f. 5a), and is from the Clinton shale at Clinton, Herkimer Co., N. Y.

CHEIRURIDAE Salter.

CHEIRURINAE Raymond.

CHEIRURUS NIAGARENSIS (Hall).

Plate 4, fig. 4, 5, 6, 9.

Ceraurus insignis Hall, Pal. N. Y., 1852, 2, p. 303, pl. 67, f. 9, 10.*Ceraurus niagarensis* Hall, 20th Rept. N. Y. state cab. nat. hist., 1868, p. 376.

? Whiteaves, Geol. surv. Canada. Pal. foss., 1884, 3, pt. 1, p. 42; 1895, 3, pt. 2, p. 107. ? Van Ingen, School of mines quarterly, Columbia univ., 1901, 23, p. 35 (no description). Kindle, 28th Ann. rept. Dept. geol. and nat. res. Indiana, p. 483, pl. 23, f. 1, 2, pl. 24, f. 8. Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 263, pl. 24, f. 20, non 21.

The name *Ceraurus niagarensis* appears for the first time on p. 376 of the first edition (1868) of the 20th Ann. Rept. of the New York State Cabinet of Natural History. Earlier in the same paper, (p. 335), Hall referred certain trilobites from the Silurian at Wauwatosa and other localities in Wisconsin to *Ceraurus insignis* (Beyrich). On p. 376 he states that he has reexamined the specimens and considers them different from *C. insignis*. The name *Ceraurus niagarensis* is used as a heading, but is not designated either as a new name or a new species. On p. 427 of the Revised edition, published in 1870, the remarks are reprinted, but the letters N.S. follow the name. In neither case is there any description of the species given, but the plates contain representations of an imperfect cranidium and a broken hypostoma.

The next use of the name by Hall was in 1879, in the 28th Rept. of the N. Y. State Museum, p. 189. He here describes the pygidium at some length from specimens obtained at Waldron, Indiana, and remarks, at the end of his description: "From the above it will be seen that the separation first made in the revised edition of the 20th Rept. St. Cab., was necessary, and that it constitutes a distinct species." The single figure given represents a pygidium.

After studying collections from a number of localities it becomes evident that the American forms now referred to *Ceraurus niagarensis* include two or three species, and it is therefore, necessary to determine the type for *C. niagarensis*. From the absence of description accom-

panying the first use of the name *niagarensis* it would appear that Hall did not apply the name to the Wisconsin specimens alone, but meant to assign this name to all American forms previously ascribed to *Cheirurus insignis* or *Ch. bimucronatus*. This idea is strengthened by the fact that he states that the New York and Wisconsin specimens show the same characteristics. He also refers to Roemer's *Ceraurus bimucronatus* from Tennessee. This idea is still further strengthened by the remark quoted above from his description of the Waldron fauna. If this is the case, then we should return to Hall's first description of a *Ceraurus insignis* in America to get at his idea of the species. If we take the other view, that the specimens from Wauwatosha, which seem to have been the first ones to cause Hall to doubt the correctness of his reference of all the Silurian cheirurids to the Bohemian species, are the real types of *C. niagarensis*, we are confronted by the fact that he did not describe his specimens, and, moreover, he was evidently in doubt about them, as evidenced by his pleasure at finding distinguishing features in the pygidia from Waldron. This latter description was the first real description published after the name *niagarensis* was proposed, and it might well be argued that the last described of the group should be the type. It seems simpler, however, to accept what was Hall's evident intent, and believe that in proposing the name *niagarensis* he was merely proposing a new name for the specimens he had previously described as *Ceraurus insignis*.

The first description of *Ceraurus insignis* Beyrich, by Hall occurs in vol. 2 of the New York State Paleontology, 1852. On page 300 there is mentioned, without description, a glabella from the Clinton which is figured on plate 66A. On page 306 of the same volume Hall describes two cranidia from the Rochester shale at Rochester, N. Y. Both specimens are figured. As these are the first American specimens which are both figured and described, I propose to designate as the type of *Cheirurus niagarensis* (Hall) the one represented in fig. 10, pl. 67, of the above volume. This specimen is in the American Museum Natural History, No. 1827.

The specimen so designated is a typical *Cheirurus*, with the glabella expanding rather rapidly forward, the frontal lobe occupying less than half the length of the glabella, and the first two pairs of glabellar furrows nearly straight, and following a direction approximately parallel to the posterior margin of the cephalon. Their inner ends are separated by a smooth space equal in width to about half the glabella. The eyes are near the dorsal furrows, and about opposite the second glabellar furrows.

This type of cranium is quite often seen in collections from the Rochester shales, but one also sees another type, the one which Hall figured from the Clinton. The cranium is similar to the one just described, but the glabellar furrows, instead of being short and straight, are long, curve backward, and their inner ends almost meet. This type of head deserves to be recognized as distinct from the other; it is the type of head figured by Hall from Wisconsin and though both types are very common there, this is by far the more abundant. To this same type, though possibly not to the same species, belongs the cephalon of *Ceraurus bimucronatus* figured by Roemer.

No entire specimen of *Cheirurus* has, so far as I know, been found in America, and it is therefore difficult to decide what pygidium shall be associated with each type of cephalon. It would appear that no *Cheirurus* pygidium had been figured from New York. The M. C. Z. possesses a single small pygidium of a *Cheirurus* from the Rochester shale at Rochester, N. Y. It is of the familiar *Cheirurus insignis* type, with three pairs of long slender spines, and a short median spine. It is very different from the pygidium from the Waldron shale ascribed to *Ceraurus niagarensis* by Hall, for that specimen was described as having broad flat spines, each spine with a depressed line on the surface.

Pygidia found at Wauwatosa are like the one from Rochester and it seems probable that this type of pygidium is to be referred to *Cheirurus niagarensis*.

The following description of *Cheirurus niagarensis* is based on three glabellas (M. C. Z. 325) and a pygidium (M. C. Z. 324) from the Rochester shale at Rochester, N. Y., and a cranium with three segments attached and an associated hypostoma, from Wauwatosa, Wis. (M. C. Z. 626). A large cranium with a part of the thorax (M. C. Z. 627) from Wauwatosa was also consulted.

CHEIRURUS NIAGARENSIS (Hall) *restricted*.

A *Cheirurus* of medium size. Cranium semicircular in outline, gently convex, the glabella forming the highest and most prominent part, but not standing much above the cheeks. The glabella reaches the front of the cranium, expands toward the front, and is widest at the middle of the frontal lobe. Dorsal furrows narrow and sharp, but not very deep. Glabellar furrows short, sharp, the first two pairs extending only a short distance onto the glabella. Their direction is

approximately vertical to the axis of the animal, but they are usually not absolutely straight, but bend a little forward in mid length. The posterior furrows run diagonally inward and connect with the neck furrow, as in the genus generally. The eyes are close to the glabella and opposite the second pair of glabellar furrows. Free cheeks small, pitted, with a smooth, convex rim. Fixed cheeks pitted. Glabella granulose. The associated hypostoma is roughly tetragonal, the surface with sharp, scattered pustules, and the posterior margin nearly straight, without spines at the angles. The furrow around the body portion is wide and deep.

Of the thorax only three segments are known. The axial lobe is narrow, the inner part of the pleural lobe is crossed by a narrow diagonal furrow which separates two triangular nodes, and there is a prominent node at the fulcrum. Beyond the fulcrum the pleuron projects as a blade-like spine.

The pygidium is short, with three pairs of slender spines which are oval in section and unfurrowed. The last pair extend further back than the ones ahead of them. A median spine is present, but very short. The axial lobe is narrow, cone-shaped, with the point backward, bearing three rings and a node. The pleural lobes are narrow, and show a single short divided rib on either side at the anterior end.

This species is very much like *Cheirurus insignis* Beyrich. The glabella seems to be a little shorter and wider in the American form, and the Bohemian species has the eyes further from the glabella and has eyelines. Of the latter, however, the specimens in the M. C. Z. show a trace. The hypostoma of the Bohemian form is similar to that of the American species, but the posterior margin is somewhat wider and more flattened. The pygidia are practically the same, though the median spine is a little stronger in *Ch. insignis*.

It will be seen from the above description, that if we restrict *Cheirurus niagarensis* to those forms which Hall first identified with *Cheirurus insignis*, we eliminate both the forms which caused him to change his mind about the identification, and propose the new name *niagarensis*. This would seem to vitiate the argument above, but it must be remembered that Hall did not recognize that he was dealing with more than one species, and he did not apply the new name to any definite specimens. In fact, it would seem that he did not become fully convinced that a new name was needed till he studied the pygidium from Waldron, and if the name *niagarensis* is not to be interpreted as has been done here, it would be almost impossible to decide whether the Wisconsin or the Waldron specimens should be selected as the types.

In spite of the similarity of *Cheirurus niagarensis*, as above defined, to *Cheirurus insignis*, I believe that a separate specific name should be maintained, especially as the discovery of further material may show unsuspected differences between the two.

Measurements:— A cranidium from Rochester (M. C. Z. 625). Length 20 mm., width 35 mm.; width of glabella at neck-ring 12 mm., at front 16 mm.; length of frontal lobe 10 mm. A cranidium from Wauwatosa, (M. C. Z. 626). Length 9 mm., width 18 mm.; width glabella at neck-ring 5 mm., width at front 8 mm.; length of frontal lobe, 3 mm.

Formation and locality:— Rochester shale at Rochester and Lockport, N. Y., Niagaran in Indiana, Wisconsin and Illinois.

CHEIRURUS WELLERI, sp. nov.

Plate 3, fig. 6; Plate 4, fig. 7, 8, 10.

Ceraurus insignis Hall, Pal. N. Y., 1852, pt. 2, p. 300, pl. 66A, f. 4. Geol.

* surv. Wisc., 1862, 1, p. 433; 18th Rept. N. Y. state cab. nat. hist., 1865, p. 31, adv. sheets; 20th Rept. N. Y. state cab. nat. hist., 1868, p. 335.

? *Ceraurus bimucronatus* Roemer, Silurian faun. west. Tenn, 1860, p. 80, pl. 5, f. 19.

Ceraurus niagarensis Hall, 20th Rept. N. Y. state cab. nat. hist., 1868, p. 376,

pl. 21, f. 10-11; 1870, rev. ed., p. 427, pl. 21, f. 10, 11; 11th Rept. Dept.

Geol. and nat. hist. Indiana, pl. 33, f. 10, non pl. 34, f. 16. Weller, Bull.

Chicago sci., 1907, no. 4, pt. 2, pl. 24, f. 21 (non 20).

The most abundant American Silurian cheirurid in the collections of the M. C. Z. is one whose glabellar furrows nearly cross the glabella, and is therefore the nearest approach to a *Crotalocephalus* so far found in America. This type has long been known, but constantly confused with *Ch. niagarensis* or *Ch. insignis*. As has already been mentioned, Hall figured one in 1852, and Roemer a similar one in 1860. The two species sometimes occur together, as at Wauwatosa, but *Ch. welleri* is easily recognized by its long glabellar furrows. A second distinction is that the posterior margin of the hypostoma is rounded in *Ch. welleri* and straight in *Ch. niagarensis*. Further, the hypostoma of the latter species is tuberculated and of the former smooth.

A large *Cheirurus* with approximately semicircular cephalon. The glabella is long, expands gradually forward. The frontal lobe occu-

pies less than half the length, and the furrows are long, curve backward, the last pair meeting, as usual, and the inner ends of the other pairs being very close together. The free cheeks are small, the eyes opposite the ends of the second pair of glabellar furrows and near the dorsal furrows. The fixed cheeks are wide, with coarse pits, and the genal spines are short and slender. The glabella seems to be devoid of granulation.

Of the thorax, only five segments have been seen. It seems to be in all respects like that of *Ch. niagarensis*. No pygidium can definitely be assigned to this species. All the specimens found at Wauwatosa seem to agree with the pygidium from Rochester which has been assigned to *Ch. niagarensis*. Weller has, however, figured a cheirurid pygidium found near Chicago, in which the central spines of the pygidium are shorter than the others. This pygidium is in this respect unlike the one here assigned to *Ch. niagarensis* and may belong to *Ch. welleri*. In cephalon and thorax, *Ch. welleri* is closely allied to *Ch. quenstedti* Barrande, of Bohemia. This species has the inner spines so short that the pygidium appears to possess only two pairs of spines. It may be that *Ch. welleri* has a pygidium intermediate in form between *Ch. insignis* or *Ch. niagarensis*; and *Ch. quenstedti*.

Measurements: — A large cranium, one of the cotypes (M. C. Z. 14) is 33 mm. long and 62 mm. wide; the glabella is 19 mm. wide at the neck-ring and 25 mm. wide at the frontal lobe; the frontal lobe is 15 mm. long. This has about the same length as *Ch. dilatatus*, but the disparity of the other dimensions should be noted. The figures for *Ch. welleri* are always given first. Length, 33, 35, width, 62, 52; width glabella at neck, 19, 20, at frontal lobe, 25, 31. The longer specimen is the narrower, and has a wider glabella, thus showing a great reduction of the cheeks. The cranium of a smaller cotype (M. C. Z. 630) is 14.5 mm. long, 25 mm. wide, the glabella is 7 mm. wide at the neck-ring, 11 mm. wide at the frontal lobe, and the frontal lobe is 7 mm. long. Large specimens of this species seem to have been abundant, and the largest glabella in the collection is 45 mm. long, and, so far as I know, the largest American cheirurid. Restored with the proportions of *Ch. insignis*, this trilobite would have a length of 145 mm. or nearly 6 inches. The Bohemian *Eccoptochile clariger* (Beyrich) equals this size.

Formation and locality: — The types are from the Niagaran at Wauwatosa, Wisc. The species occurs also in the Clinton of New York, the Waldron of Indiana, Silurian of Tennessee, and Guelph of Ontario. It is probably the most cosmopolitan species of Cheirurus.

CHEIRURUS DILATATUS, sp. nov.

Plate 4, fig. 1, 3.

Sphaerexochus romingeri ? Hall, 28th Rept. N. Y. state mus. nat. hist., 1877, doc. ed., pl. 32, f. 16.

Ceraurus (Cheirurus) niagarensis Hall, 28th Rept. N. Y. state mus. nat. hist., 1879, mus. ed., p. 189, pl. 32, f. 16; 11th Ann. rept. Dept. geol. and nat. hist. Indiana, 1882, p. 335, pl. 34, f. 16, non pl. 33, f. 10.

In the discussion of *Cheirurus niagarensis* (p. 30) frequent mention has been made of the pygidium from Waldron which Hall figured. This pygidium differs radically from the pygidia which have been referred to *Ch. niagarensis* and *Ch. welleri*, in having broad, short spines, each marked by a depressed line. This appearance of the spines is probably due to crushing, in so far as the depressed line is concerned, but the spines are decidedly shorter and broader than those of the species previously described.

Cheirurids seem to be rare at Waldron for a search through an extensive collection from that locality in the M. C. Z. has revealed only one good cranidium, one poor one, and a pygidium. The best specimen is a fairly well-preserved cranidium, having much the general appearance of *Ch. niagarensis*, only larger. On a closer examination of the proportions, however, it is seen that this form is longer and narrower than the typical specimens of *Ch. niagarensis*, and the glabella makes up a larger proportion of the cephalon. In a specimen of *Ch. niagarensis* from Rochester (M. C. Z. 625) the length is .57 of the width and in the specimen from Waldron (M. C. Z. 628) it is .67. In the first species the width of the frontal lobe of the glabella is less than half the width of the cephalon (.46). In the latter specimen it is somewhat more (.60). These appear, in figures, relatively small differences, but when the areas involved are compared it is at once seen that the glabella of the Waldron specimen is much larger than that of the specimens of *Ch. niagarensis*.

It is of course uncertain whether the pygidium described by Hall is to be associated with the cranidium here discussed. It may belong to the same species, and they are provisionally associated. The cranidium is, however, made the holotype of the species, and the pygidium a paratype.

A large Cheirurus. The cranidium is dominated by the glabella, whose frontal lobe is more than one half as wide as the total width

of the head. The glabella expands rapidly forward, the frontal lobe occupies less than one half the length, and the glabellar furrows are like those of *Cheirurus niagarensis*. The free cheeks are small, the eyes opposite the ends of the second pair of furrows, and a little further from the glabella than in *Ch. niagarensis*. The surface of the cheeks shows numerous pits, while the glabella is granulose. Genal spine rather long and straight.

Only one kind of *Cheirurus pygidium* has been found at Waldron. The spines are short and subequal in length, broad, and flat. The ribs on the pleural lobes are distinctly separated by furrows, and the first rib on each side has a short sharp diagonal furrow. The median unpaired spine at the back is about one half as long as the ones adjacent to it.

Measurements:—The type is 35 mm. long, 52 mm. wide; the glabella is 31 mm. wide at the front and 20 mm. wide at the neck-ring; the frontal lobe is 17 mm. long.

Formation and locality:—Found only in the Waldron shale at Waldron, Indiana.

CHEIRURUS PATENS, sp. nov.

Plate 4, fig. 2.

This species, like the previous one, is notable for the small size of its cheeks. The glabella is of the *insignis* type, with short furrows, but is rather more convex and prominent than in that species. It expands rapidly toward the front, and the frontal lobe is a little longer than in any other species of the genus, forming a trifle more than one half the length of the glabella of the type. The outline of the frontal lobe is almost exactly semicircular, and thus differs from most of the other specimens seen, the ordinary outline being that of half an ellipse. Since the first pair of glabellar furrows are a little further back than on most species, the fixed cheeks which terminate here are shorter than usual, and the eye is a little further back.

The cheeks are full of pits, and the glabella granulose. The posterior glabellar lobes are not strictly triangular but pentagonal, a statement which is true of most species of *Cheirurus*, but more obvious than usual in this species.

Measurements:—Length about 31 mm., width, about 53 mm.; width glabella at frontal lobe 26 mm., length frontal lobe 17 mm.

Formation and locality:—The type is a single imperfect cranium

from the "Niagara" at Cicero, Illinois (M. C. Z. 629). A second specimen, tentatively referred to this species, is in the Museum of the Geological Survey of Canada, and is from the Guelph of Hespeler, Ontario.

CHEIRURUS TARQUINIUS Billings.

Cheirurus tarquinius Billings, Proc. Portland soc. nat. hist., 1863, 1, p. 121, pl. 3, f. 22.

This is a little-known species of the *Ch. insignis* group. It has a short, wide cephalon, narrow triangular basal lobes on the glabella, a short frontal lobe, and the first two pairs of furrows turn backward, are quite straight, and are intermediate in length between those of *Ch. niagarensis* and *Ch. welleri*. The species is especially characterized by the forward position of the eyes, which are opposite the second glabellar lobes, and the consequent small free cheeks and long fixed cheeks. The genal angles appear to be spineless.

The type is No. 3081 in the Museum of the Geological Survey of Canada. Associated with it is a pygidium from the same locality. It is of the *insignis* type, with three pairs of spines, but the median spine is shorter and more rounded than in either *Ch. insignis* or *Ch. niagarensis*. A poorly preserved hypostoma in the same collection has the posterior end more rounded than that of *Ch. niagarensis*, and thus more like that of *Ch. welleri*.

Measurements: — The type (G. S. C. 3081) is 19 mm. long, 35 mm. wide; and the glabella is 12 mm. wide at the neck-ring and 17 mm. wide at the frontal lobe.

Formation and locality: — Middle Silurian at Port Daniel, Bay, Chaleur, P. Q., Canada. Also reported by Billings from Masardis, Maine.

CHEIRURUS HYDEI (Weller).

Ceraurus hydei Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 264, pl. 24, f. 22.

This species is of more than ordinary interest, from its resemblance to a *Ceraurus*. The cephalon and thorax are those of a typical *Cheirurus*, but the pygidium is that of *Ceraurus*. This at once raises the question as to whether this is a *Cheirurus* which has developed a *Ceraurus*-like pygidium, or whether it is a *Ceraurus* whose cephalon and thorax have developed in a manner paralleling that of *Cheirurus*.

There is still a third possibility, namely, that *Ceraurus hydei* is the young of *Cheirurus niagarensis*, with which it occurs. On this third point, Weller states that the fixed cheeks of *C. hydei* lack the pitted surface characterizing *C. niagarensis*, and that *C. hydei* has a border all around the cephalon, while *C. niagarensis* lacks it in front of the glabella. These facts seem to be borne out by the type which is now before me, and Professor Weller might have added that the glabella expand more rapidly in the young of *C. niagarensis* than in *C. hydei*, and has deeper glabellar furrows. The eyes too, of the young of *C. niagarensis* are much further back than those of *C. hydei*.

Against these differences we may, however, place the fact that the thorax is alike in the two species, and more similar to the thorax of *Cheirurus insignis* Beyrich than to any of the Ordovician species of *Ceraurus*. In both *Cheirurus niagarensis* and *Ceraurus hydei*, the part of each pleural lobe between the dorsal furrow and the fulcral line is very much reduced, the diagonal furrow is very short, and the two small nodes which it separates are narrow, and one directly in front of the other, a point not brought out in Weller's somewhat generalized figure. On the fulcral line there is a row of nodes, and just inside this row is a longitudinal furrow parallel to the dorsal furrows. Beyond the fulcral line, the pleura are free, not contiguous as shown in Weller's figure. These same characteristics are shown in two specimens of *Cheirurus niagarensis* from Wauwatosa, Wisconsin.

On the whole, it does not seem very probable that *C. hydei* is the young of *Cheirurus niagarensis*, especially as there is another species, *Ceraurus nuperus* (Billings) which has a *Cheirurus*-like cephalon and *Ceraurus*-like pygidium. The choice seems to lie between calling it a *Ceraurus* or a *Cheirurus*. Theoretically, it would seem that the *Ceraurus* pygidium was more specialized, and, therefore, less apt to be duplicated than the *Cheirurus* head. Most of the other *Cheiruridae*, except *Ceraurus*, have all the spines of the pygidium approximately equal.

In *Ceraurus pleurexanthemus* there is a tendency in some specimens to have the basal lobes of the glabella triangular instead of square, and in *Ceraurus misneri* the glabella occupies a large part of the cephalon, and the cephalon is long. Further, *Ceraurus* reaches the climax of size and abundance in the Trenton, the late species being smaller, and the specimens rarer. As to the thorax, I have shown that this portion of the test changes in parallel directions in many lines of the *Asaphidae*, and the same might well happen in the *Cheiruridae*. On the other hand, one would not expect a decadent race to show new characters similar to those of a race which is at its best.

Though no other cheirurid exactly duplicates the *Ceraurus* pygidium, there are numerous cases among the trilobites referred to the genus *Cheirurus* in which there is a reduction of the inner pairs of spines of the pygidium. Thus, Weller has figured a *Cheirurus* pygidium from Lemont, near Chicago, in which spines of the inner pair are shorter than the others. In *Cheirurus quenstedti* there are only two pairs of spines, the inner pair being reduced to mere rudiments. In *Cheirurus hawlei* there is a still further reduction, so that there is only one pair of long spines, thus producing a pygidium which is a parallel to that of *Ceraurus*, though differing considerably from it in detail. The typical number of segments in a *Cheirurus* pygidium seems to be five, a protopygidium and four pairs of coalesced segments which originally had free spines. Among the species referred to *Cheirurus* by Barrande may be seen *Ch. minutus* Barrande with four pairs of spines, *Ch. bifurcatus* with four pairs, the central pair partly united, *Ch. insignis* and many others with three pairs and a central spine. In England, *Ch. bimucronatus* with three pairs without the central spine. In Bohemia again, *Ch. quenstedti* Barrande with two pairs of spines and two rudiments, *Ch. hawlei* Barrande with one pair spines and four rudiments, and in America *Ch. hydei* Weller and *Ch. nuperus* Billings with one pair of spines and three rudiments. Differences in the cephalon show that this is not a progressive (or regressive) series, but apparently a number of cases of parallel development by the loss of the posterior inner pairs of spines.

In view of this general tendency among the cheirurids to a reduction of the spines of the pygidium, it seems that more weight should be given to the cephalon than to the pygidium in determining relationships, and *Ch. hydei* and *Ch. nuperus* are therefore referred to *Cheirurus*. It may be proper, when the family has been more fully studied, to erect a new genus for these peculiar species. The M. C. Z. has recently acquired a fairly complete specimen (M. C. Z. 631) of this species, of which only two other specimens are now known. The specimen is from an unknown locality near Chicago, Ill. This specimen shows that the eye is very far forward, opposite the first pair of glabellar furrows. Both the genal and pygidial spines are longer than had been supposed, and as pointed out above, the pleura of the thorax, beyond the line of nodes denoting the fulcra, are free blade-like spines.

Measurements: — The specimen figured by Weller is 24 mm. long, 14.5 mm. wide at the genal angles, and the glabella is 5 mm. wide at the back.

Formation and locality: — Known only from the Niagaran near Chicago, Illinois.

CHEIRURUS NUPERUS Billings.

Cheirurus nuperus Billings, Cat. Silurian fossils Anticosti, 1866, p. 60, f. 20.

This species was described from an isolated glabella and pygidium from Div. 3 at East Point, Anticosti. Schuchert and Twenhofel have listed it with a query from the upper part (D9) of their Gun River formation, where it is associated with *Bilobites bilobus* and *Triplecia ortonii*, in strata of Clinton age.

Like *Ch. hydei*, this species shows the *Cheirurus* type of basal lobes on the glabella and the pygidium shows three pairs of spines. The outer pair or great spines are large, flat and not so long or so much curved as in most of the species of the genus. *C. hydei* has the great spines much more slender and further apart than in *C. nuperus*.

The type of this species is lost, and no further specimens have been described.

SPHAEREXOCHUS ROMINGERI Hall.

Sphaerexochus romingeri Hall, 20th Rept. N. Y. state cab. nat. hist., 1868, p. 375, pl. 21, f. 4-7. (See Weller, Bull. Chicago acad. sci., 1907, no. 4, pt. 2, p. 209, for earlier and later references to this species).

This is an exceedingly common species in the Niagaran in the Chicago and Wisconsin areas but the pygidium is rare and usually incorrectly figured. Hall started the misrepresentation figuring the pygidium as having three spines on each side and a rounded projection at the back.

As a matter of fact, the margin of the pygidium is entire, and the spines figured by Hall are the ribs on the pleural lobes. Weller produced practically a similar figure, and one of Kindle's is about the same, but the other, being of a mould, is more correct. Other describers of the species have refrained from figuring the pygidium.